WO 98/29847 09/341093 PCT/GB98/00015

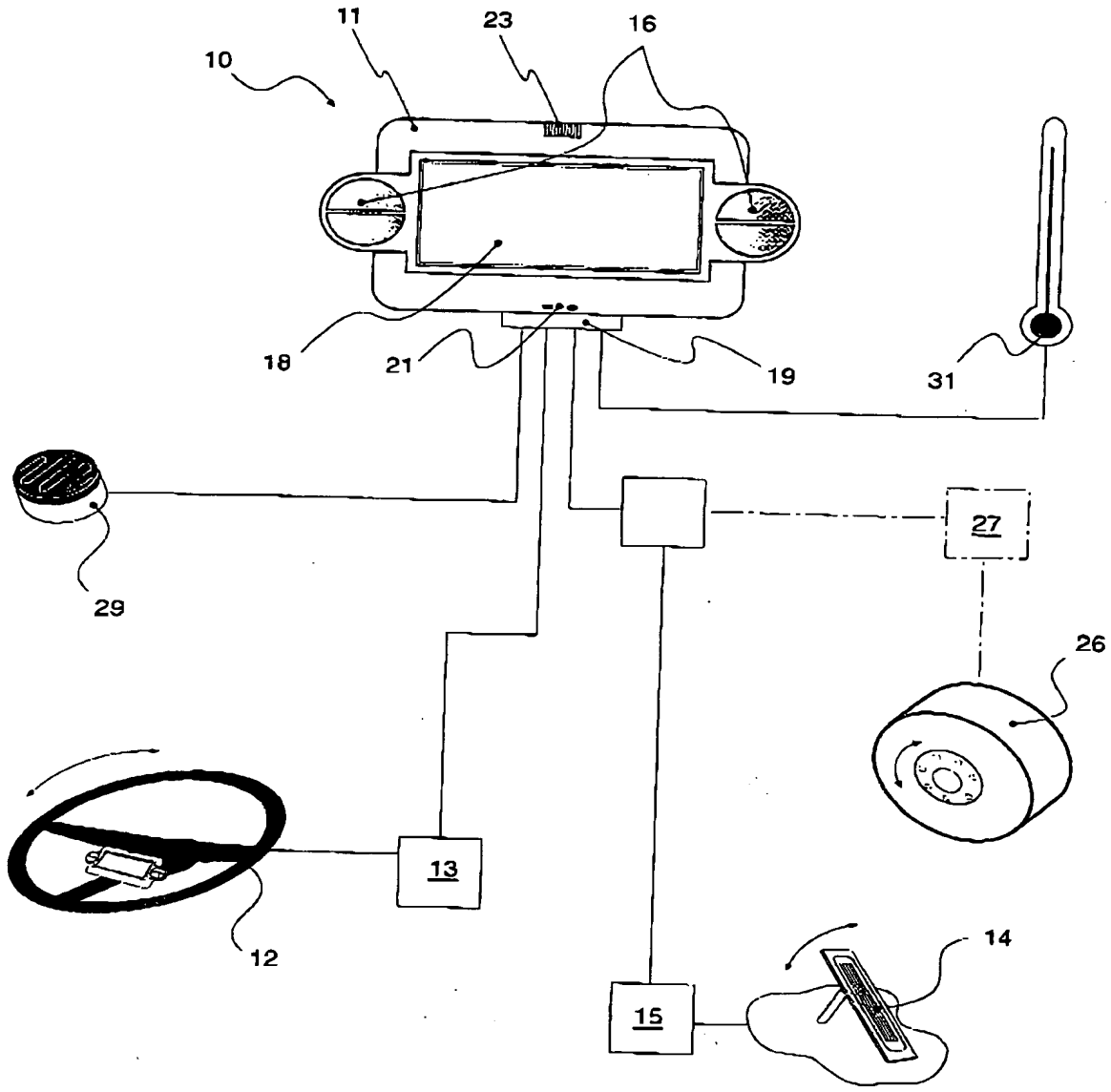


Figure 1

WO 98/29847

09/341093

PCT/GB98/00015

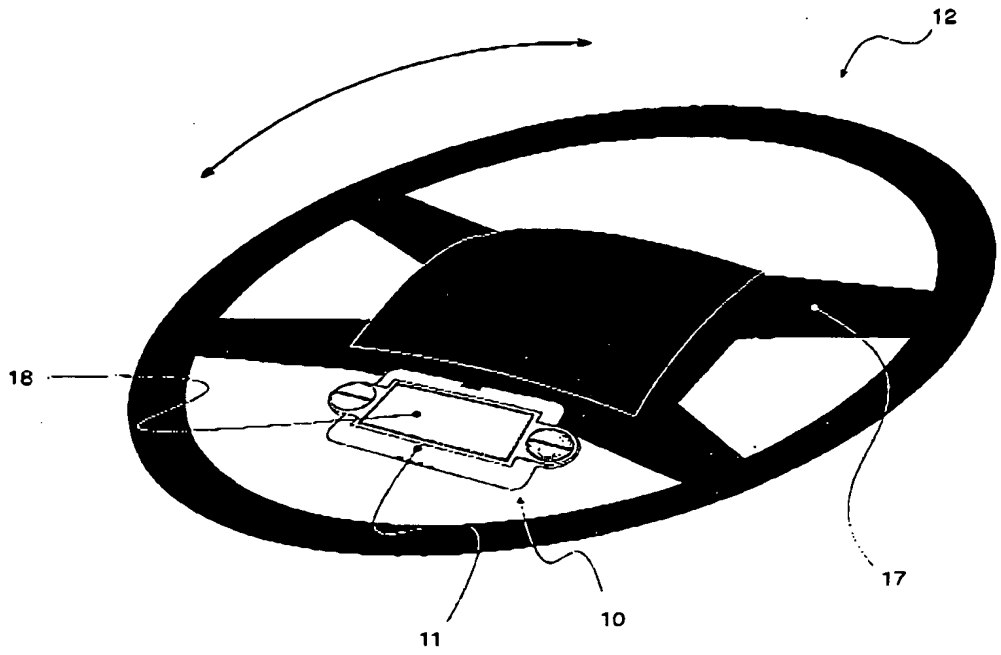


Figure 2

LIKELIHOOD OF FALLING ASLEEP 1= unlikely, 2= possibly, 3= likely, 4= very likely, 5= certain

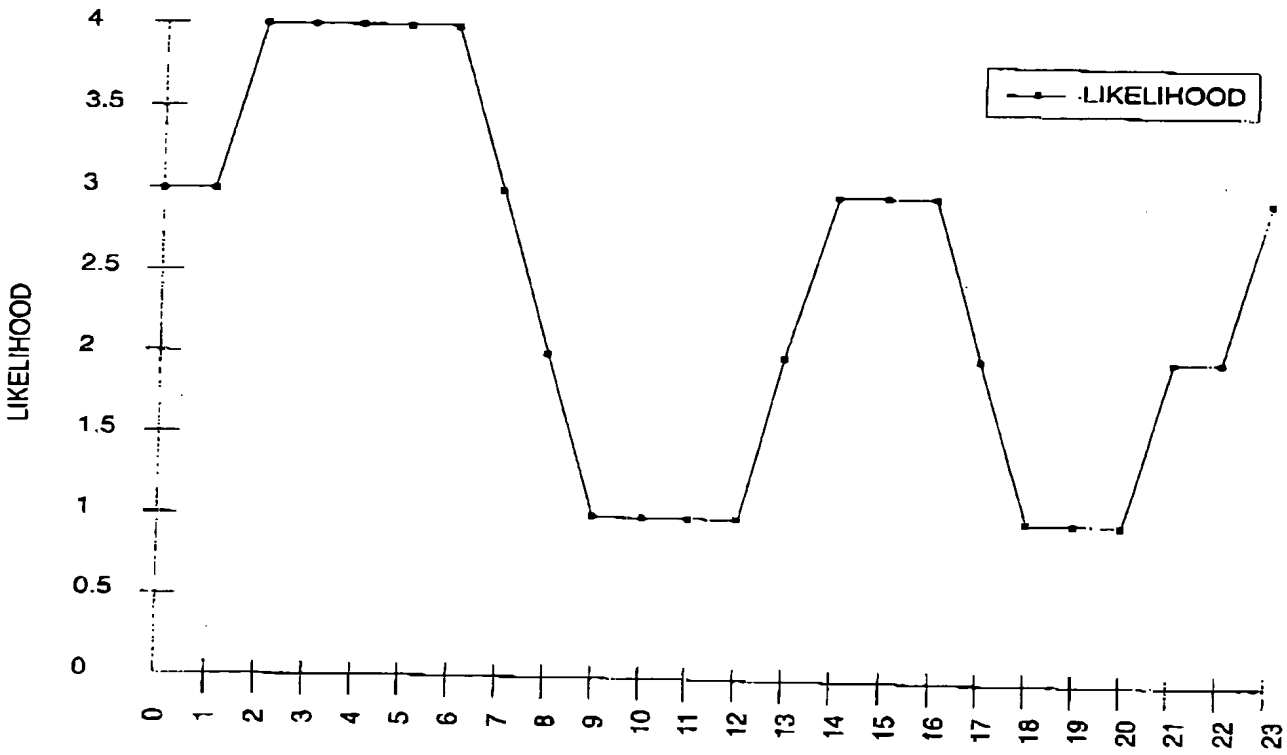


Figure 3

WO 98/29847 09/341093 PCT/GB98/00015

Figure 4

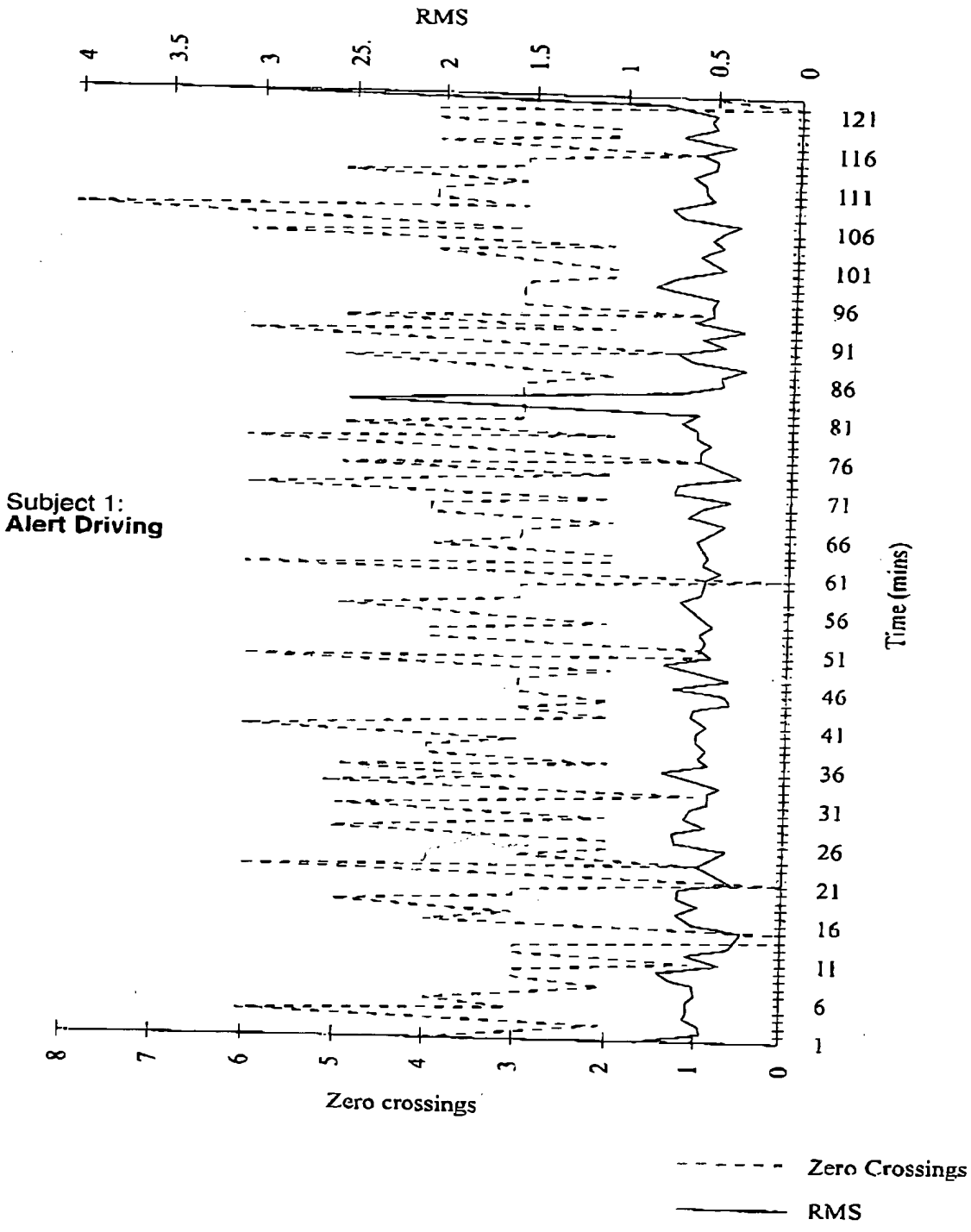


Figure 5

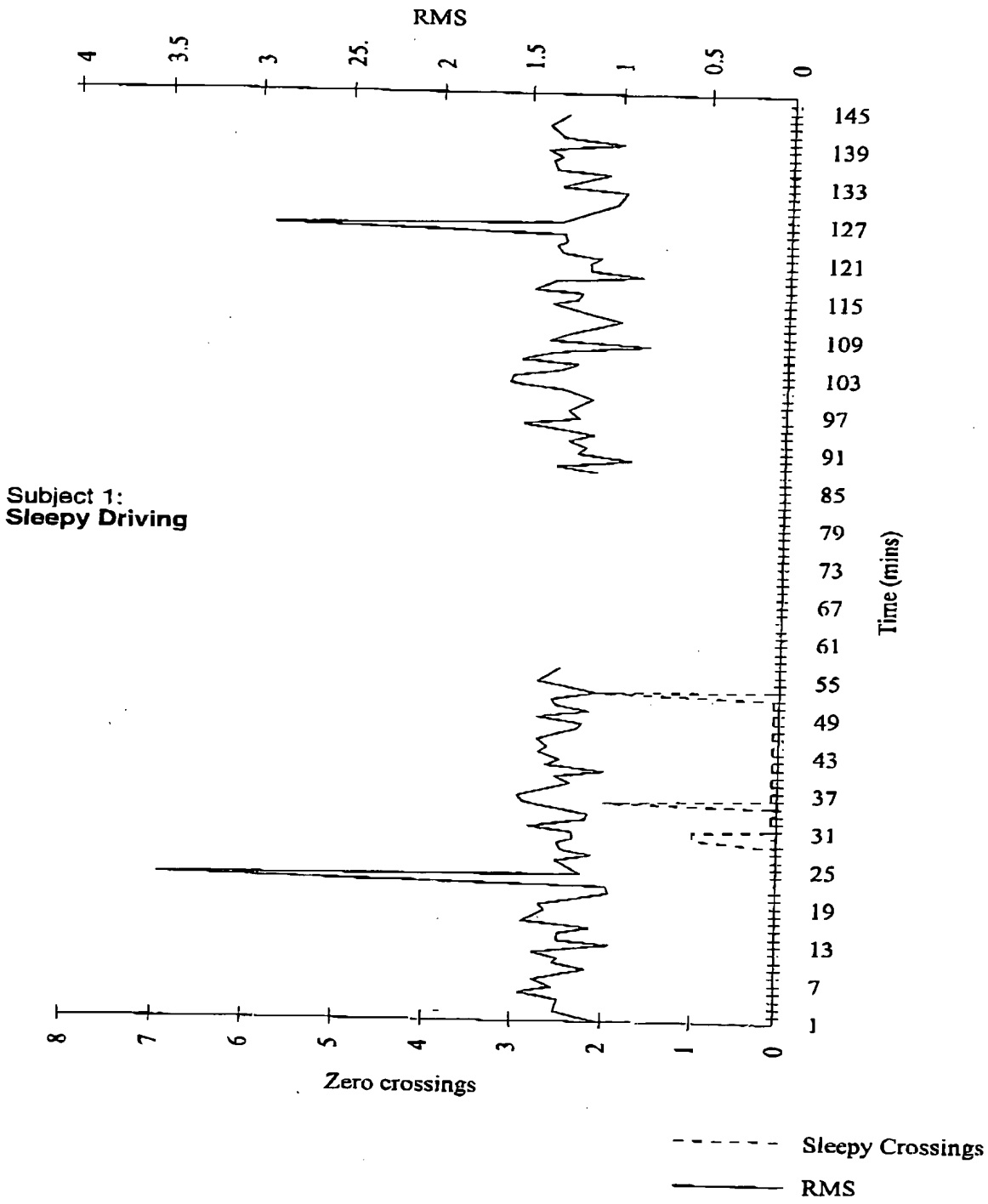
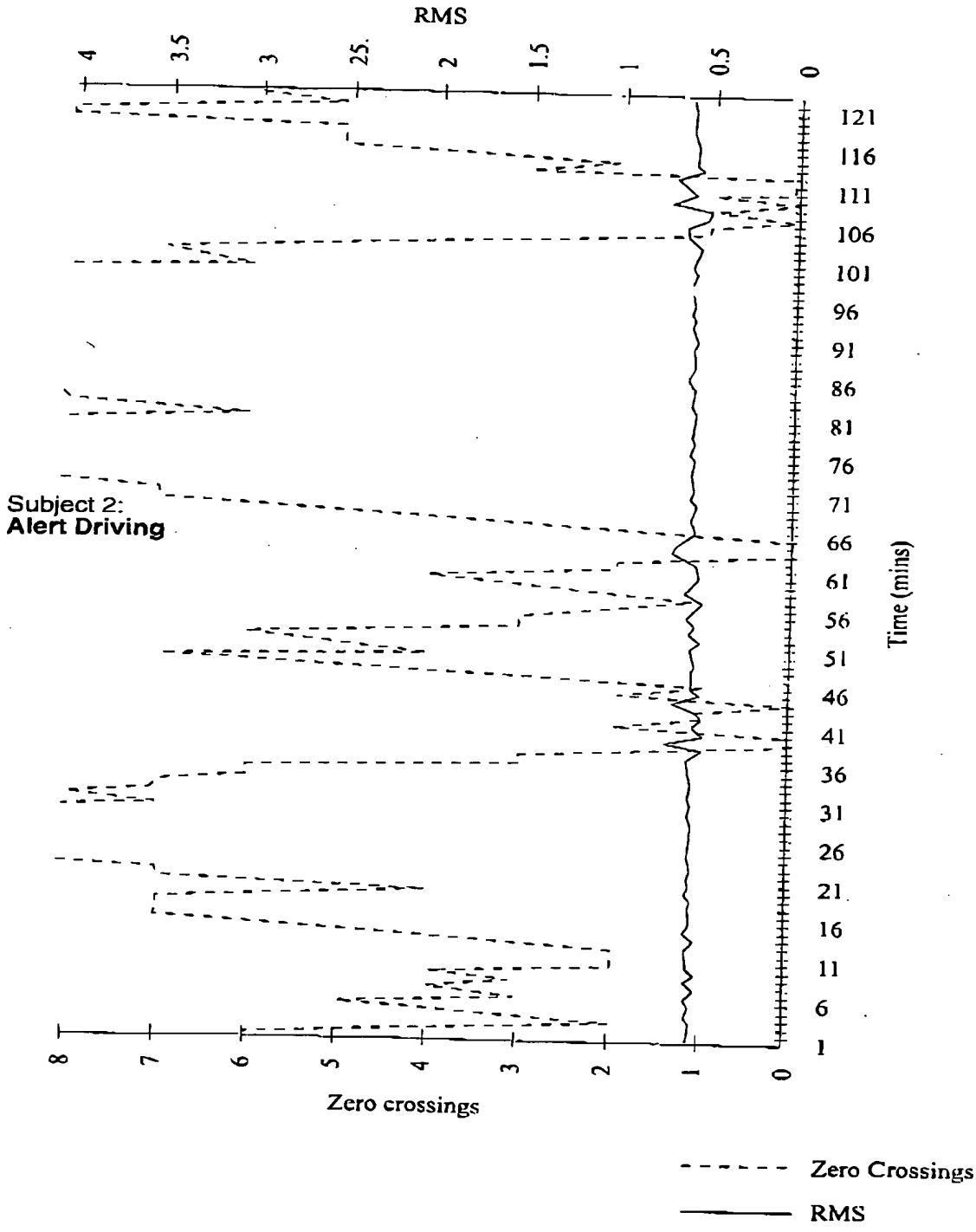
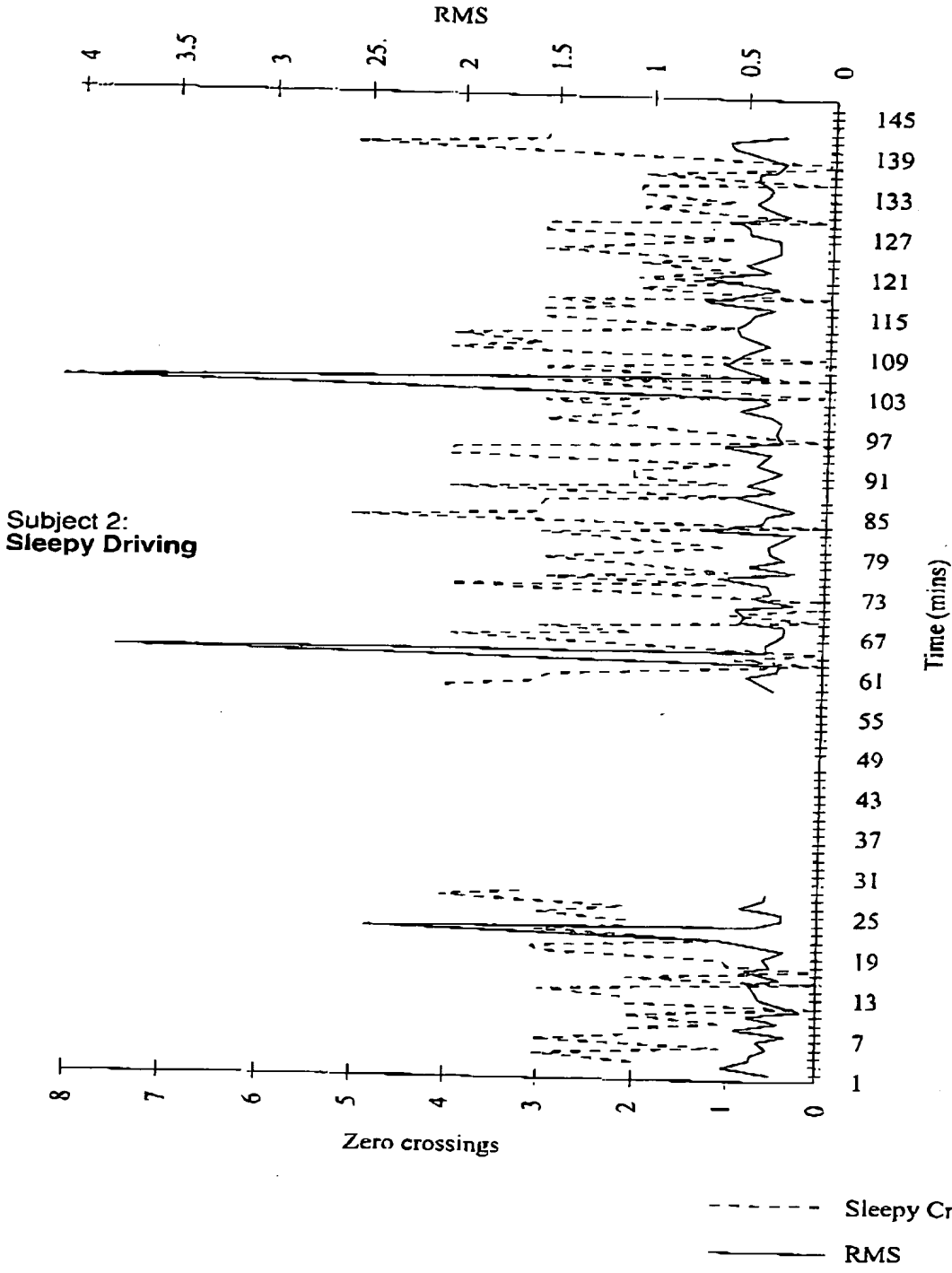

RMS
4
3.5
3
2.5
2
1.5
1
0.5
0
145
139
133
127
121
115
109
103
97
91
85
79
73
67
61
55
49
43
37
31
25
19
13
7
1
Time (mins)
Subject 1:
Sleepy Driving
8
7
6
5
4
3
2
1
0
Zero crossings
Sleepy Crossings
RMS

Figure 6


RMS
4
3.5
3
2.5
2
1.5
1
0.5
0
121
116
111
106
101
96
91
86
81
76
71
66
61
56
51
46
41
36
31
26
21
16
11
6
1
Time (mins)
Subject 2:
Alert Driving
8
7
6
5
4
3
2
1
0
Zero crossings
Zero Crossings
RMS

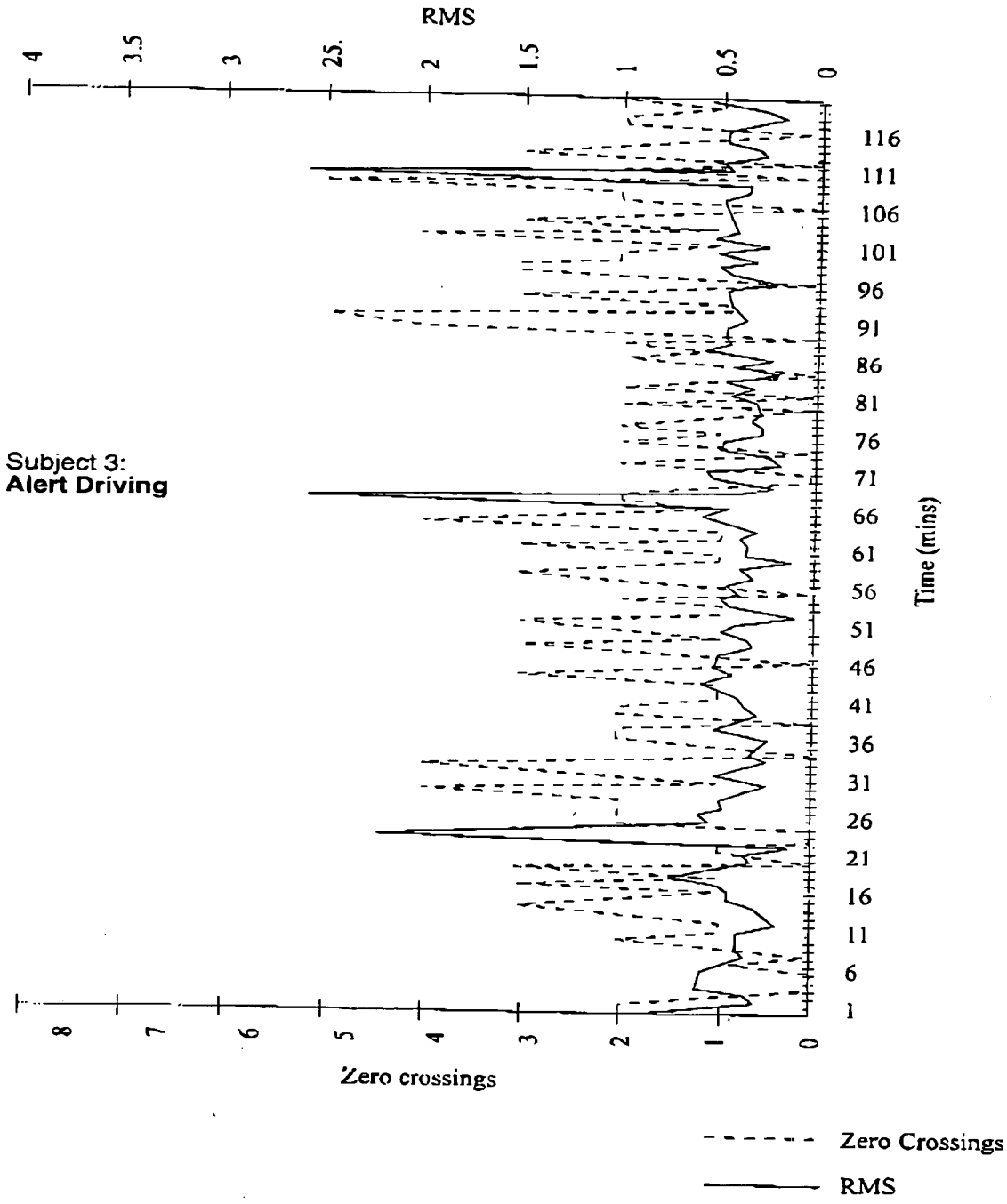
WO 98/29847 09/341093 PCT/GB98/00015

Figure 7



WO 98/29847 09/341093 PCT/GB98/00015

Figure 8



WO 98/29847 09/341093 PCT/GB98/00015

Figure 9

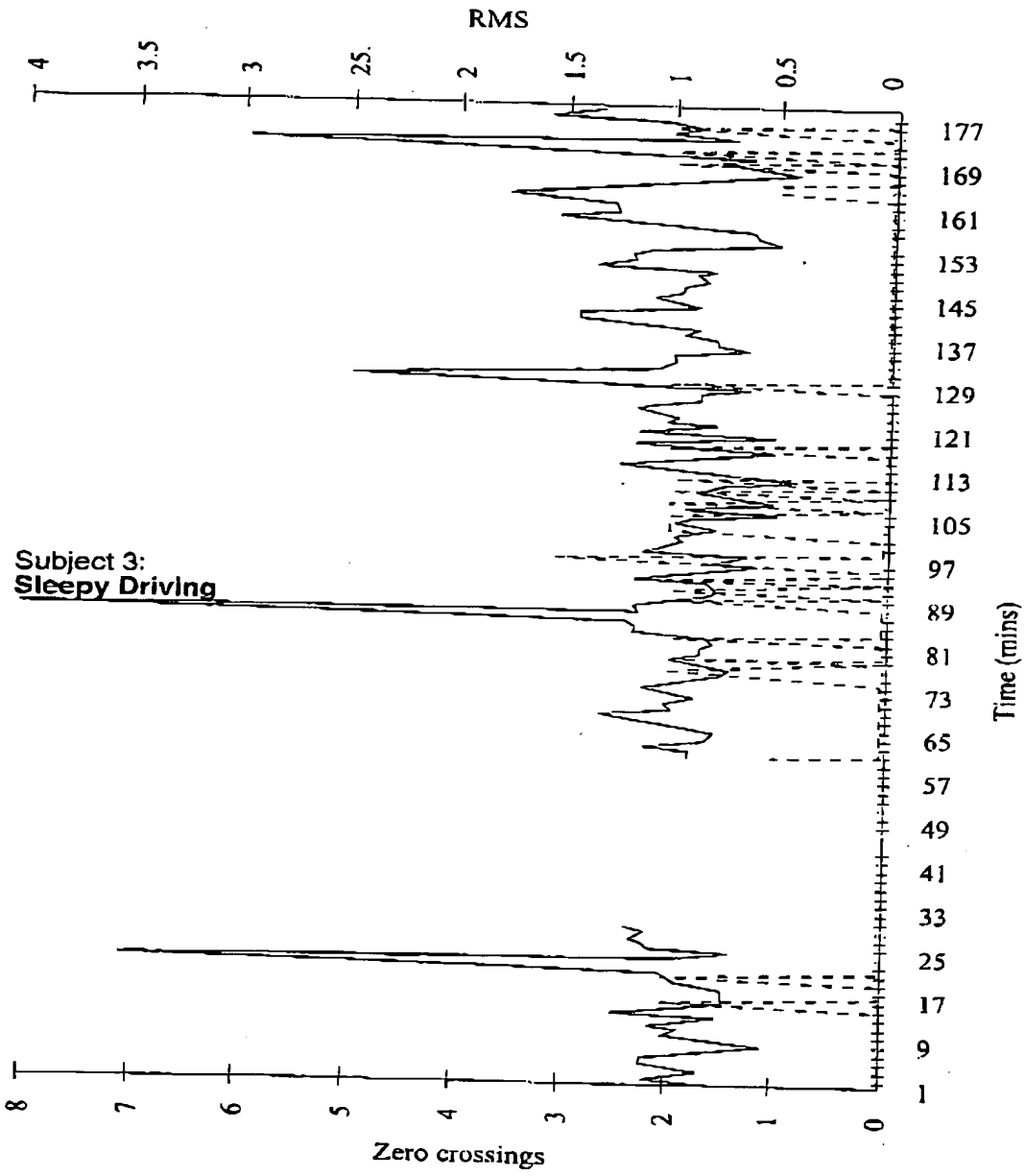


Table 1

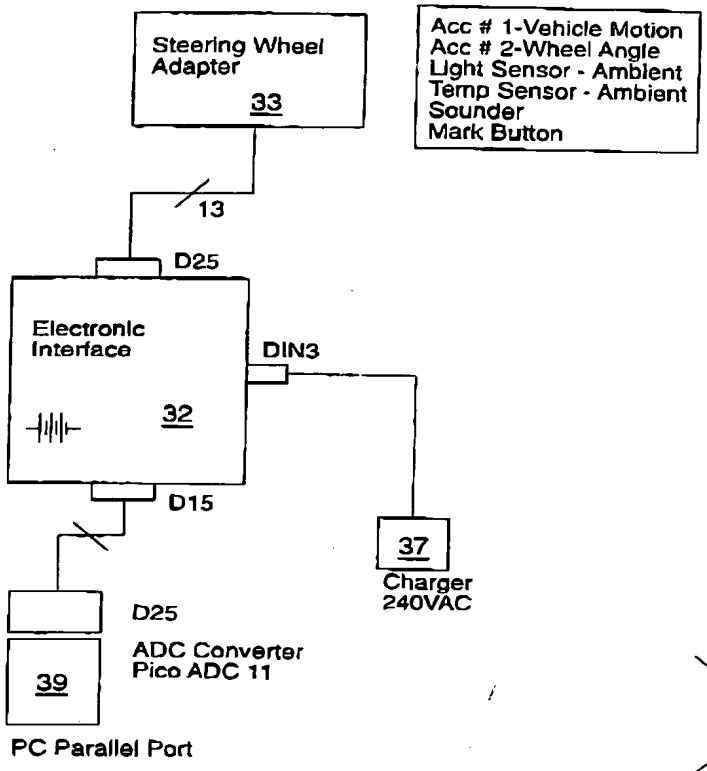


Figure 10

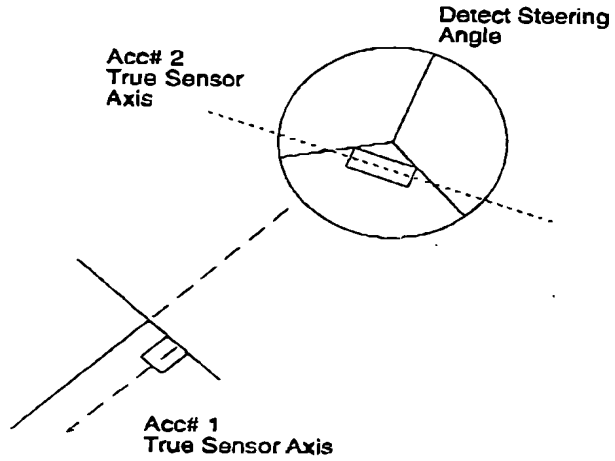


Figure 11

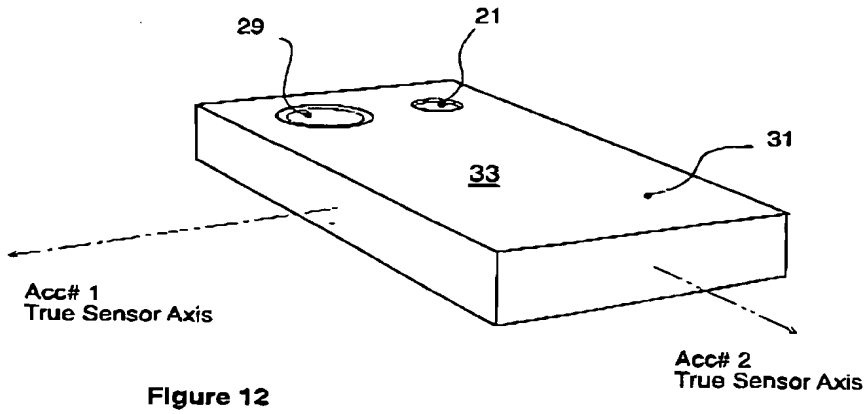


Figure 12

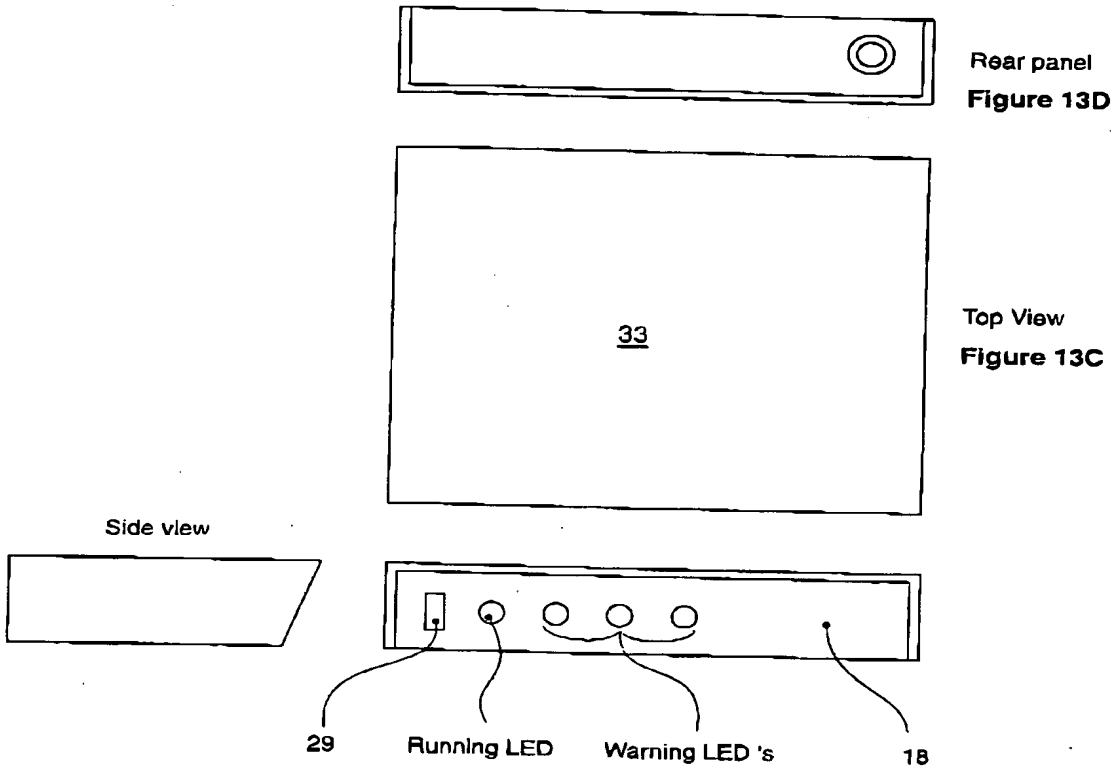


Figure 13D

Figure 13C

Figure 13B

Figure 13A

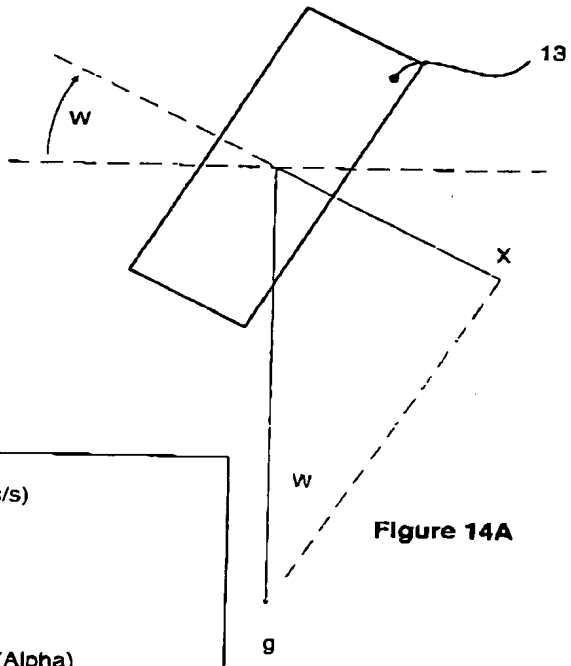


Figure 14A

Table 2

W - Wheel Rotation Angle X - Measured component of g in sensor axis (m/s/s) K wheel - Sensor scaling factor (mm/s/s/bit) g - Gravity 9.81 m/s/s g - Gravity Vector Component in wheel Plane
Sin W = X / g
X = k wheel / 1000 x (Ch(1)-ZeroWheel) x 1/Cos(Alpha)
Sin W = k wheel / (1000 x g)x(Ch(1)-ZeroWheel)x(1/Cos(Alpha)
W + ArcSin [Kwheel /(1000 x g)x(Ch(1)-ZeroWheel)x 1/Cos(Alpha)]

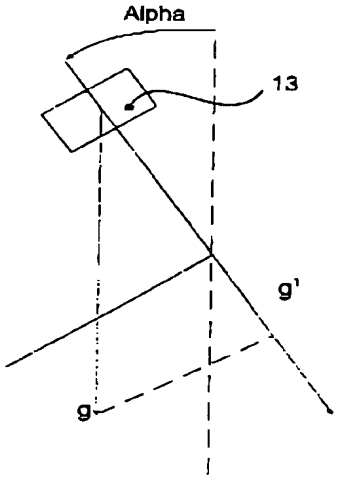


Figure 14B

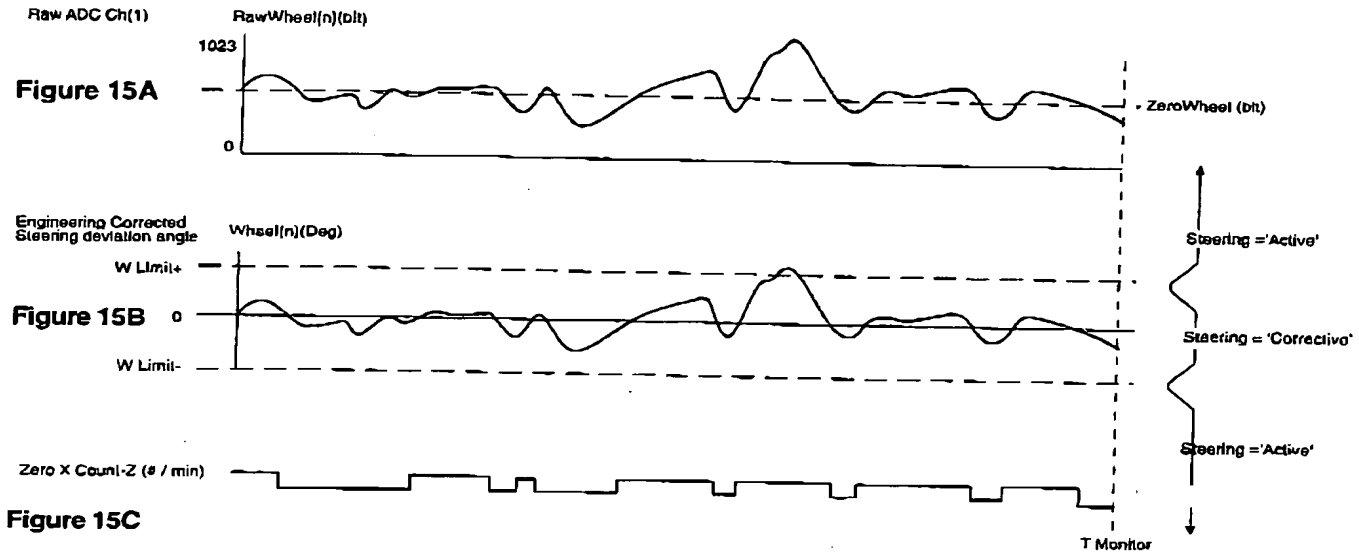


Figure 15A

Figure 15B

Figure 15C

Table 3

RMS Steering Angle- R(Deg) = $\sqrt{\frac{\sum Wheel[n]^2}{n}}$

Table 4

Bound Check	
W Limit- < W < W Limit+	Steering Mode=Corrective
W < W Limit-	Steering Mode=Active
W > W Limit+	Steering Mode=Active

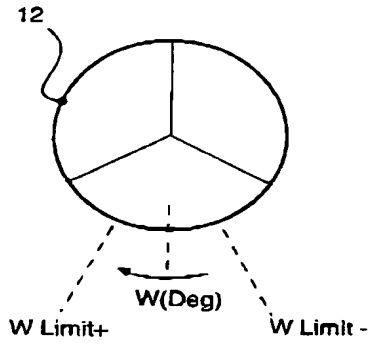


Figure 15D

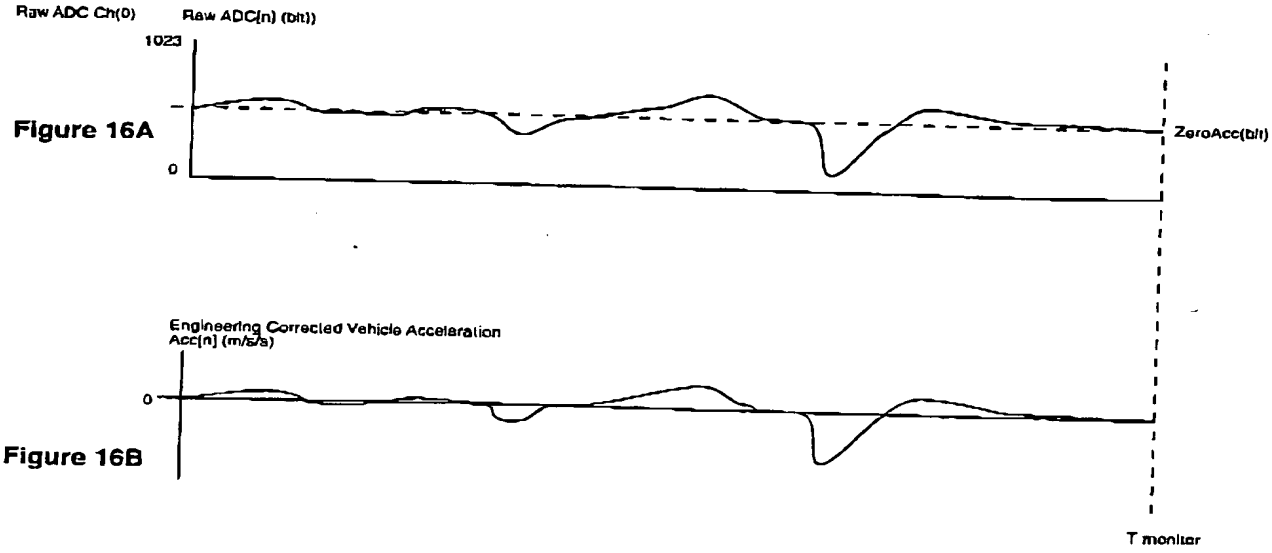


Figure 16A

Figure 16B

Table 5

$$\text{RMS Vehicle Acceleration-G(m/s/s)} = \sqrt{\frac{\sum \text{Acc}[n]^2}{n}}$$

WO 98/29847 09/341093
PCT/GB98/00015

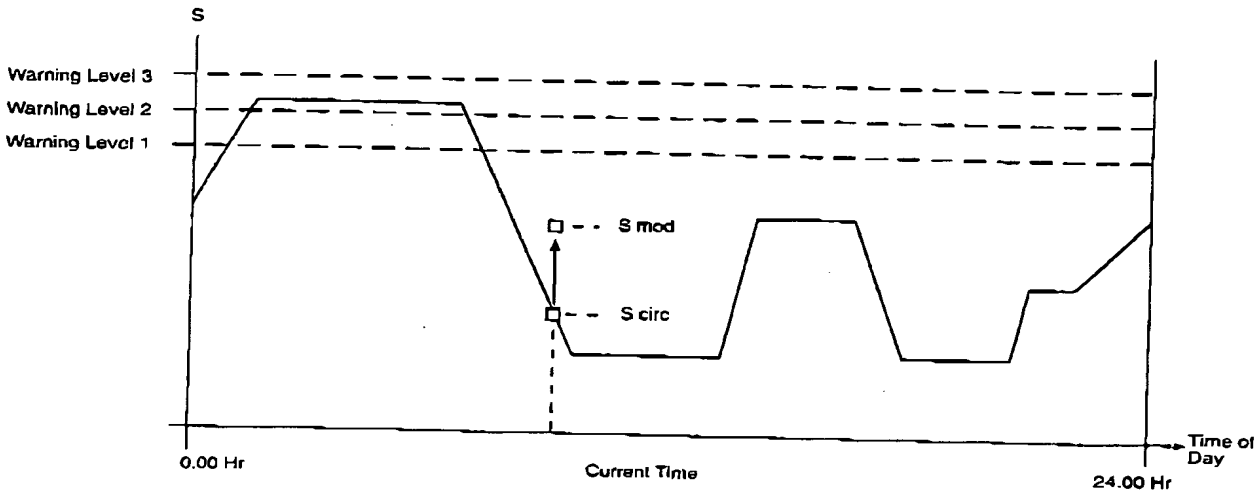


Figure 17

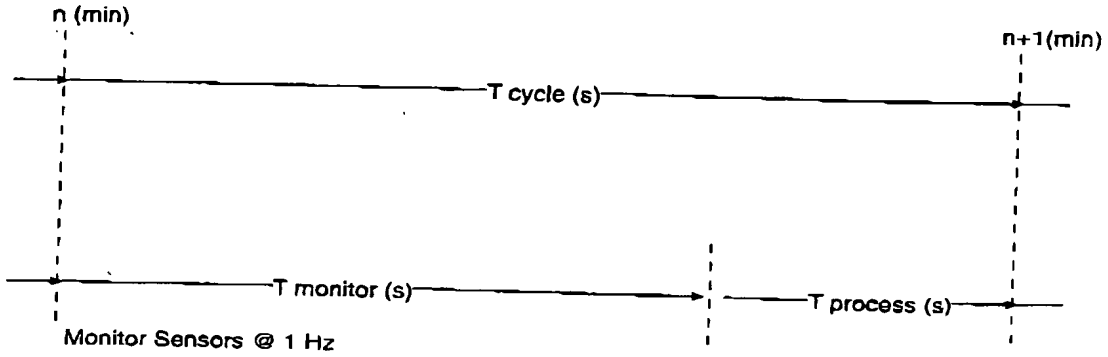


Table 6

T cycle = 60s T monitor = 50s T process = 10s	Calculate Parameters Test & Issue Warnings Update Screen Display Store Sensor Data > Disk Store Calculated Parameters > Disk

Figure 18

Figure 19

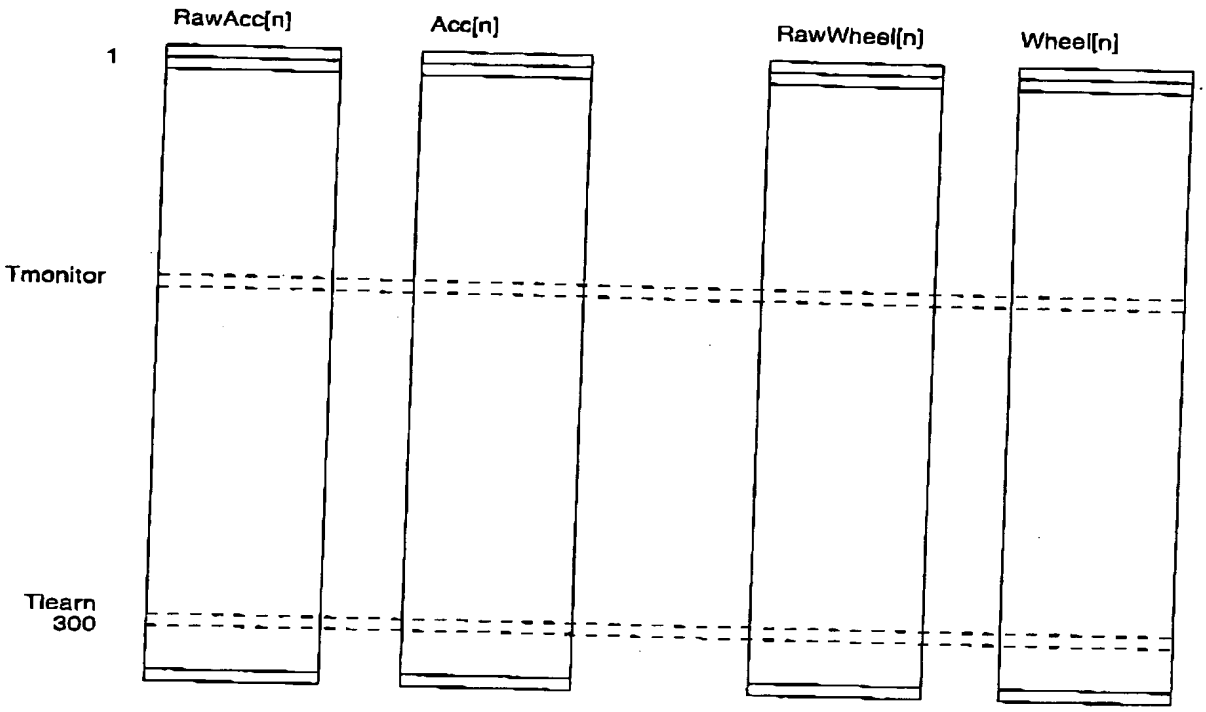


Table 7

Note:
Data storage @ 1Hz ZeroAcc=Average {RawAcc[n]} ZeroWheel=Average {RawWheel[n]} Ch(N)=Raw ADC Value (bit)

Table 8

Acc[n] = Kacc/1000 x (RawAcc[n]-ZeroAcc)x1/Cos(Alpha) (m/s/s) (mm/s/s/bit) (bit) (bit)
Wheel[n] = ArcSin [Kwheel/(1000x9.81) x (RawWheel[n]-ZeroWheel)x1/Cos(Alpha)] (Deg) (mm/s/s/bit) (bit) (bit)
I = Klight/1000 x (Ch(2)-ZeroLight) (KLx) (Lx/bit) (bit) (bit)
T = Ktemp/1000 x (Ch(3) - ZeroTemp) (DegC) (mDegC/bit) (bit) (bit)

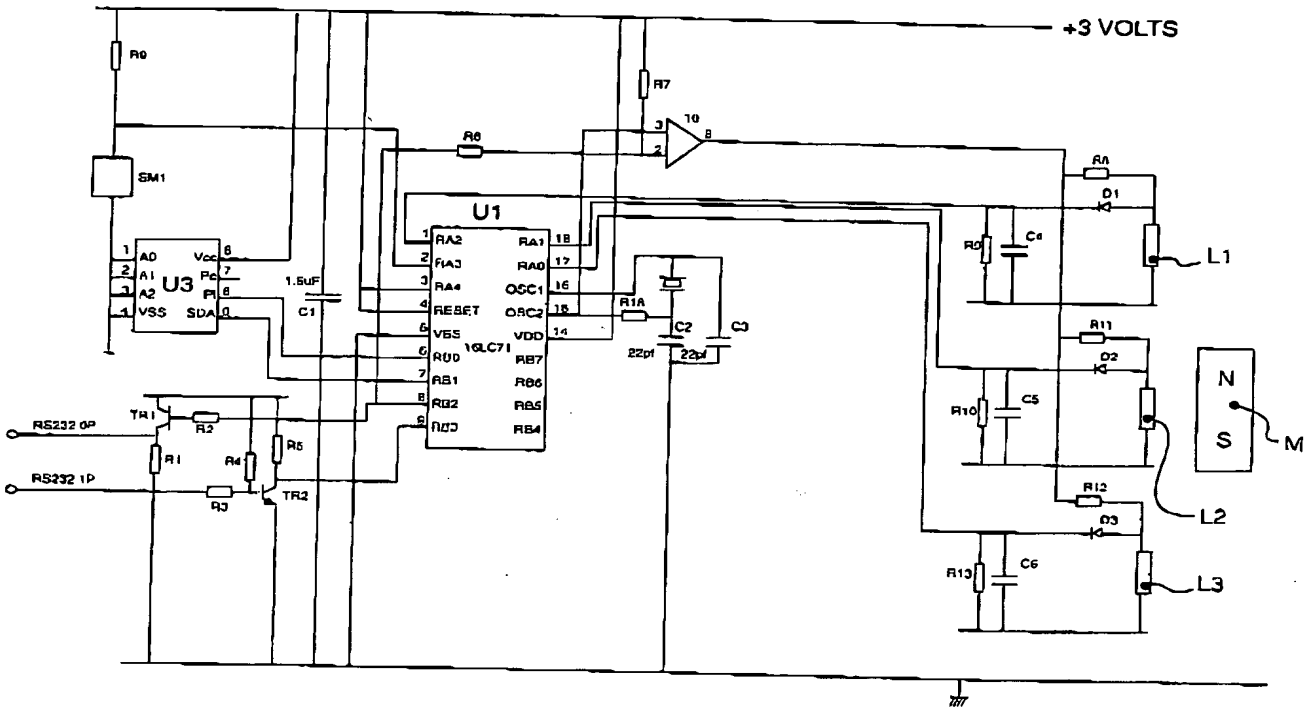

+3 VOLTS
R0
R7
R8
SM1
U1
U3
1.5uF
C1
R1A
C2
C3
22pf
22pf
RS232 0P
RS232 1P
TR1
TR2
R1
R2
R3
R4
R5
R6
R9
D1
C4
L1
R11
D2
C5
R10
N
S
M
L2
R12
D3
C6
R13
L3

Figure 21

Table 1

Acc # 1-Vehicle Motion
Acc # 2-Wheel Angle
Light Sensor - Ambient
Temp Sensor - Ambient
Sounder
Mark Button

Table 2

W - Wheel Rotation Angle
X - Measured component of g in sensor axis (m/s/s)
K wheel - Sensor scaling factor (mm/s/s/bit)
g - Gravity 9.81 m/s/s
g - Gravity Vector Component in wheel Plane

Sin W = X / g

X = k wheel / 1000 x (Ch(1)-ZeroWheel) x 1/Cos(Alpha)

Sin W = k wheel / (1000 x g)x(Ch(1)-ZeroWheel)x(1/Cos(Alpha)

W + ArcSin [Kwheel /(1000 x g)x(Ch(1)-ZeroWheel)x 1/Cos(Alpha)]

Table 3

RMS Steering Angle- R(Deg) = $\sqrt{\frac{\sum \text{Wheel}[n]^2}{n}}$

Table 4

Bound Check	
W Limit- < W < W Limit+	Steering Mode=Corrective
W < W Limit-	Steering Mode=Active
W > W Limit+	Steering Mode=Active

Table 5

RMS Vehicle Acceleration-G(m/s/s) = $\sqrt{\sum \frac{Acc[n]^2}{n}}$

Table 6

T cycle = 60s T monitor = 50s T process = 10s	Calculate Parameters Test & Issue Warnings Update Screen Display Store Sensor Data > Disk Store Calculated Parameters > Disk

Table 7

Note:

Data storage @ 1Hz
ZeroAcc=Average {RawAcc[n]}
ZeroWheel=Average {RawWheel[n]}
Ch(N)=Raw ADC Value (bit)

Table 8

Acc[n] = Kacc/1000 x (RawAcc[n]-ZeroAcc)x1/Cos(Alpha)

(m/s/s) (mm/s/s/bit) (bit) (bit)

Wheel[n] = ArcSin [Kwheel/(1000x9.81) x (RawWheel[n]-ZeroWheel)x1/Cos(Alpha)]

(Deg) (mm/s/s/bit) (bit) (bit)

I = Klight/1000 x (Ch(2)-ZeroLight)

(KLx) (Lx/bit) (bit) (bit)

T = Ktemp/1000 x (Ch(3) - ZeroTemp)

(DegC) (mDegC/bit) (bit) (bit)

Table 9

Engineering Scaling Factors	
K acc (mm/s/s/bit)	Acceleration Channel
K wheel (mm/s/s/bit)	Steering Channel
K light (Lx/bit)	Light Channel
K temp (mDegC/bit)	Temp Channel
ZeroLight (bit)	Intercept adjust - Light
ZeroTemp (bit)	Intercept adjust - Temp
Alpha (Deg)	Steering Wheel Inclination from Vertical
Hysterisis (Deg)	Hesterisis factor - Zero X analysis

Table 10

Sleep Propensity Algorithm - Definition	
S mod=S circ + S zerox + S rms + S light + S temp + S sleep + S road + S trip	
Elemental	Bound Limit
S mod	0<S mod <1
S circ	0<S circ <1
S zerox = (F zerox/100) (Z ref-Z)	0<S zerox
S rms = (F rms/100) (R-R ref)	0<S rms
S light = (F light/100) (I ref -I)	0<S light
S temp = (F temp/100) (T -T ref)	0<S temp
S sleep = (F sleep/100) (H ref - (HxQ))	0<S sleep
S road = (F road/100) (G ref -G)	0<S road
S trip = (F trip/100) x D	0<S trip

Table 11

Algorithm Elementals - S	
S mod (S)	Modified Sleep Propensity Factor-Range 0...1
S circ (S)	Current Circadian Sleep Propensity Value
S zerox (S)	Current Corrective Steering Reversal Rate Deficit
S rms (S)	Current RMS Corrective Steering Amplitude Surfit
S light (S)	Current Ambient Lighting Intensity Deficit
S temp (S)	Current Ambient Temperature Surfit
S sleep (S)	Prior Sleep Good Hours Deficit
S road (S)	Current Road Activity Deficit
S trip (S)	Accumulated Trip Duration

Table 12

Algorithm Weighting Factors - F	
Note : Factors are % S Unit per Parameter Unit	
F zerox (%S/#/min)	Corrective Steering Reversal Rate Deficit - % Factor
F rms (%S/Deg)	RMS Corrective Steering Amplitude Surfit - % Factor
F light (%S/kLx)	Average Ambient Lighting Intensity Deficit - % Factor
F temp (%S/DegC)	Average Ambient Temperature Surfit - % Factor
F sleep (%S/Hr)	Prior to Good Hours Sleep Deficit - % Factor
F road (%S/m/s/s)	Road Activity Deficit - % Factor
F trip (%S/Hr)	Accumulated Trip Duration - % Factor

Table 13

Algorithm Reference Offfsets - ref	
Z ref (#/min)	Corrective Steering Reversal Rate - Ref Offset Corresponds to 'Alert ' Driving Subject Dependent
R ref (Deg)	Corrective Steering RMS Amplitude - Ref Offset Corresponds to 'Alert ' Driving Subject Dependent
I ref (kLx)	Average Ambient Lighting Intensity - Ref Offset Corresponds to moderate daylight
T ref (DegC)	Average Ambiont Temperature - Ref Offset Corresponds to moderate environment
H ref (Hr)	Prior to Good Hours Sleep - Ref Offset Corresponds to optimum value
G ref (m/s/s)	Road Activity - RMS Acceleration / Deceleration - Ref Offset

Table 14

Algorithm Dynamic Variables	
Z (#/min)	Current Corrective Steering Zero X Rate
R (Deg)	Current RMS Correvtive Steering Amplitude
I (kLx)	Current Ambient Lighting Intensity
T(DegC)	Current Ambient Temperature
G (m/s/s)	Current Road Activity - RMS Acceleration / Deceleration
D(Hr)	Accumulated Trip Duration
H(Hr)	Actual Hours of Prior Sleep
Q (#)	Prior Sleep Quality - Normalised Scale 0...1
Qx (#)	Prior Sleep Quality User Scale 1,2,3,4,5 Q=Qx/5

Table 15

Steering Mode & Steering Limit -W limit	
W limit (Deg)	Decision limit - Steering mode detection +W limit >W> -W limit >>> Corrective +W limit <W< -W limit >>> Active
Steering Mode	Steering mode decision ACTIVE, CORRECTIVE

Table 16

Alarm Levels & Alarm State	
Alarm Level 1 (s)	Alarm level threshold
Alarm Level 2 (s)	Alarm level threshold
Alarm Level 3 (s)	Alarm level threshold
Alarm Holdoff (min)	Initial alarm forced hold-off time - N minutes
Alarm State	Alarm status decision CLEAR, LEVEL1, LEVEL2, LEVEL3, HOLDOFF

Table 17

User Software Functions	
Set Display Parameters	
Enter New Values and <RET> or <RET> to bypass edit option.	
Display History (min)	Graphic display history length - Last N minutes
FSD (S)	Graphic display full scale - S unit (0.. 1)

Table 18

Data Directiory Structure
[ALGO] *.ALG Algorithm Data Files - Internal Format
[USER]*.ALG User Data Files - Internal Format
[XALGO]*.CSV Algorithm Data Files - CSV Formal
[XUSER]*.CSV User Data Files - CSV Format
[XDRIVE]*.CSV Drive Mode Data Files - CSV Format
[XLEARN]*.CSV Learn Mode Data Files - CSV Format

Table 19

File Structure - Program Internal Format	
Note : These files in program internal readable format	
Configuration File - SLEEPALT.CFG	
Save Set Values @ Program Shut Down Load Set Value @ Program Initialisation	
K acc	(mm/s/s/bit)
K wheel	(mm/s/s/bit)
K light	(Lx/bit)
K temp	(mDegC/bit)
K batt	(mV/bit)
ZeroLight	(bit)
ZeroTemp	(bit)
Hysterysis	(Deg)
Alpha	(Deg)
AlgorithmID	
UserID	
Circ[0] ... [23]	(S)
FSD	(0.. 1)
DisplayHist	(min)

Table 20

Algorithm Data File [ALGO]*.ALG	
F zerox	(%S/#/min)
F rms	(%S/Deg)
F light	(%S/Klx)
F temp	(%S/DegC)
F sleep	(%S/Hr)
F road	(%S/m/s/s)
F trip	(%s/Hr)
Z ref	(#/min)
R ref	(Deg)
I ref	(KLx)
T ref	(DegC)
H ref	(Hr)
G ref	(m/s/s)
Alarm1	(s)
Alarm2	(s)
Alarm3	(s)
AlarmHoldoff	(min)
W limit	(Deg)

Table 21

User Data File [USER]*.USR
UserName
UserDoB
UserSex

Table 22

Data File Structure - Drive Mode Data File [XDRIVE]*.CSV
Note: These files in external readable format - CSV

DriveID
File Ceation Date
Start Time (Hr 0.. 23)
Start Time (min 0.. 59)
UserID
AlgorithmID

Alarm1 (s)
Alarm2 (s)
Alarm3 (s)
AlarmHoldOff (min)

W limit (Deg)

H (Hr)
Q (0.. 1)

F zerox (%S/#/min)
F rms (%S/Deg)
F light (%S/kLx)
F temp (%S/DegC)
F sleep (%S/Hr)
F road (%S/m/s/s)
F trip (%S/Hr)

Z ref (#/min)
R ref (Deg)
I ref (Kix)
T ref (DegC)
H ref (Hr)
G ref (m/s/s)

Minute Count (min) ..... Repeat 1 .. N(min)
AlarmState
SteeringMode
Acceleration [1](m/s/s) Wheel[1](Deg)

Acceleration [50] Wheel[50]

Z (#/min)
R (Deg)
I (KLx)
T (DegC)
G (m/s/s)
D (Hr)

S mod (S)
S clrc (S)
S zerox (S)
S rms (S)
S temp (S)
S sleep (S)
S road (S)
S trip (S)

DQC (Data Quality Code 0..255)

Table 23

Data File Structure - Learn Mode Data File [XLEARN]*.CSV

Note : These files in external readable format - CSV

Data File Structure - User Data File [XUSER]*.CSV

Note : These files in external readable format - CSV

UserID
File Creation Date

UserName
UserDoB
UserSex

Table 24

Data File Structure - Algorithm Data File [XALGO]*.CSV

Note : These files in external readable format - CSV

AlgorithmID

File Creation Date

F zerox (%S/#/min)

F rms (%S/Deg)

F light (%S/kLx)

F temp (%S/DegC)

F sleep (%S/Hr)

F road (%S/m/s/s)

F trip (%S/Hr)

Z ref (#/min)

R ref (Deg)

I ref (KLx)

T ref (DegC)

H ref (Hr)

G ref (m/s/s)

Alarm1 (s)

Alarm2 (s)

Alarm3 (s)

AlarmHoldOff (min)

W limit (Deg)